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Porosity structure of green polybag of medium density fiberboard from seaweed waste

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Abstract. The last decade shown that the needs Medium Density Fibreboard (MDF) rapidly growing in Asia Pacific and Europe up to more 15 % per year. MDF made up of fibers lignoselulosa which combined with synthetic resin or tied other suitable but high temperatures and pressure. Technology engineering for green polybag of MDF from seaweed waste of *Kappaphycus alvarezii* and *Gracilaria verrucosa* is an alternative effort for ecosystem stability and technological innovations that is environmentally friendly. Structure porosity from the shape of green polybag shows that performance seaweed waste of *K. alvarezii* is better than seaweed waste of *G. verrucosa*. The circulation of water happened more optimal in green polybag formed from MDF of seaweed waste of *K. alvarezii* with size porosity 3.976 μm, while size porosity of seaweed waste of *G. verrucosa* measurable 4.794 μm. Structure of green polybag of MDF from seaweed waste showed that C components greater 50 % to *K. alvarezii* while C components less than 50 % to *G. verrucosa*. This resulted in the ties to structure of MDF stronger found in green polybag derived from seaweed waste of *K. alvarezii* than *G. verrucosa*.

1. Introduction

Polybags have been used for planting seeds until today. The use of polybag has some disadvantages, including the fact that the roots of plants grow in circle in the plastic bag and the plastic used as polybag material is not easily degradable by the environment or microorganisms living in the soil, causing the increasing in the accumulation of plastic waste [1]. Plant growth process often creates the problem of drought due to the use of water for watering plants. Drought occurs in the growth phase and causes considerable decline in the crop yields [2]. In the last decade, the needs for Medium Density Fibreboard (MDF) grew rapidly in Asia Pacific and Europe by more than 15 % per year. MDF is made from lignocellulosic fibers combined with synthetic resin under high temperatures and pressures. A major component of MDF is lignocellulose, that can be obtained from wood, hay, herbage, farming waste, forest, or industrial waste (wood, paper and other fibrous materials). Lignocellulose contains three major components, namely cellulose, hemicellulose, and lignin. The waste of *Kappaphycus alvarezii* and *Gracilaria verrucosa*, from which carrageenan is extracted, and agar that has enough lignocellulose content are the materials needed for making MDF. Ilknur and Cirik [3] stated that seaweed is not only used as food. Its utilization as a pharmaceutical ingredient and industrial raw material also needs to be explored further. Indonesia's dried seaweed production of 800.000 tons/year since 2010 has contributed to 50 % of the world's production, and 85 % of that amount has been exported. By the importers, the seaweed is processed into food industrial materials as well as health and cosmetics products. Indonesia has 34 seaweed processing industries in which seaweed is processed into gelatin, alginate and carrageenan. However, the use of seaweed waste as a useful product has not been the center of attention. The waste generated is usually only left accumulating at landfills. Although it is harmless, the waste dump may cause pollution problems, especially if the landfills are no longer able to accommodate waste [4]. The engineering of green polybag of MDF made from the waste of *K. alvarezii* and *G. verrucosa* is an effort to maintain ecosystem stability and is an environmentally friendly technological innovation.

Based on the problem explained above, it is necessary to conduct research related to the waste of *K. alvarezii* and *G. verrucosa* as a raw material of MDF as a substitute for polybags with optimum and efficient water volume for the optimization of seaweed waste and reduction of the use of plastic to avoid environmental damages because of the use of polybags. The results of this research suggested that this prototype was able to reduce water consumption by exploring the structure porosity of the shape of green polybag.

2. Method

2.1. Materials

The tools used included: a cylindrical iron plate with an upper diameter of 7 cm, a bottom diameter of 6.5 cm and a height of 6 cm, functioning as a tool for the first printing; a cylindrical iron plate with an upper diameter of 11 cm, a bottom diameter of 9.5 cm and a height of 8 cm, functioning as a tool for printing both polybags; a lamp; an oven; a fitting; a stirrer; a basin; an analytical scale; and a ruler. The raw materials used were the waste of *G. verrucosa* obtained from farmers in Jabon, Sidoarjo and the waste of *K. alvarezii* obtained from seaweed farmers in Sumenep, Madura. The wood powder was obtained from the remnants of wooden furniture around Tempurejo, and the adhesive material was obtained from a hardware strore in Surabaya.

2.2. Sample preparation

Preparation included the collection of raw materials such as seaweed waste, wood powder and adhesive. The range of adhesive used in the dry process was 8—11% of the board dry weight. This experiment consisted of eight treatments, namely: G0: structure porosity from the shape of green polybag showing the performance waste of *G. verrucosa* (0 day); G7: structure porosity from the shape of green polybag showing the performance of waste of *G. verrucosa* (7 days); G14: structure porosity from the shape of green polybag showing the performance of waste of *G. verrucosa* (14 days); G21: structure porosity from the shape of green polybag showing the performance of waste of *G. verrucosa* (21 days); K0: structure porosity from the shape of green polybag showing that performance of waste of *K. alvarezii* (0 day); K7: structure porosity from the shape of green polybag showing the performance of waste of *K. alvarezii* (7 days); K14: structure porosity from the shape of green polybag showing the performance of waste of *K. alvarezii* (14 days); and K21: structure porosity from the shape of green polybag showing the performance of waste of *K. alvarezii* (21 days). The water volume was determined by the first particle board based on the pot to be filled with soil media for growing plants, and the pot based on the second particle board held water during the research. The water requirement of plants was determined based on the value of water content in the state of the field capacity [5].

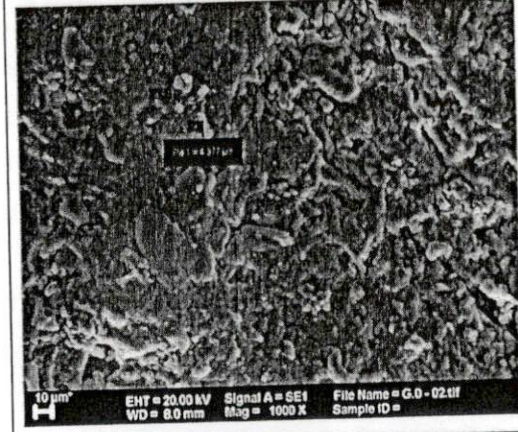
Before doing the forging phase, the seaweed waste was cleaned. Then, it was dried naturally for ±3 days and by using an oven to decrease the water content. The next stage was grinding the seaweed to obtain seaweed powder, which was filtered using a 40 mesh sieve. The other materials prepared were 100 mesh wood powder for mixture and synthetic adhesive additives.

2.3. Medium density fiberboard (MDF)
The making of MDF was done by a dry process using a hot press. After the raw material was mixed with adhesive, the mixture was pressed using a hot press at a temperature of 170 °C and a pressure of 45 Pa for 25 minutes [6]. The first particle board was cylindrical with an upper diameter of 7 cm, a height of 6.5 cm and a bottom diameter of 6 cm. The second particle board pot had an upper diameter of 11 cm, a height of 8 cm and a bottom diameter of 9.5 cm. Then, re-conditioning was conducted for two days to get a high-quality particle board.

2.4. Research parameters
In this research, the main parameter observed was physical test of the structure porosity of MDF. The structure porosity of MDF from the shape of green polybag showing the performance of seaweed waste was tested using a scanning electron microscope in the study of identification of structure porosity and mineral contents. The other parameters measured during the research were temperature, soil pH and soil moisture that were to be used for testing the results of the research.

2.5. Statistical analysis
The experimental research and the data analysis were conducted using ANOVA (Analysis of Variance), and the design used was Completely Random Design, with the aim to determine the manufacturing of MDF with seaweed waste as the main material, which could replace polybags. If the results obtained were significant, they would be tested further using Duncan's test [7].

3. Results and Discussion
The structure porosity from the shape of green polybag showing the performance of waste of K. alvarezii was better than that of the waste of G. verrucosa. Within 21 days, the water circulation was more optimal in green polybag formed from MDF made of the waste of K. alvarezii with size porosity of 3.976 µm, while the size porosity of the MDF made of the waste of G. verrucosa was measured 4.794 µm. The structure of green polybag of MDF from seaweed waste showed that the carbon content in K. alvarezii was greater than 50%, but less than 50% in G. verrucosa. On the other hand, the structure of green polybag of MDF from seaweed waste showed that the oxygen content was greater than 50 % in G. verrucosa, but less than 50% in K. alvarezii. This caused the bonds in the structure of MDF stronger in green polybag derived from seaweed waste of K. alvarezii than G. verrucosa. Meanwhile, the structure porosity of MDF which stayed open allowed the greater availability of oxygen and increased the productivity of the growing media.

<table>
<tr><th>Treatment</th><th>Structure Porosity</th><th>Mineral Content</th></tr>
<tr><td>G_0</td><td>
</td><td>
<table>
<tr><th>El</th><th>AN</th><th>Series</th><th>unn. C [wt. %]</th><th>norm. C [wt. %]</th><th>Atom. C [at. %]</th><th>Error [%]</th></tr>
<tr><td>O</td><td>8</td><td>K-series</td><td>49.32</td><td>49.32</td><td>45.97</td><td>30.8</td></tr>
<tr><td>C</td><td>6</td><td>K-series</td><td>39.57</td><td>39.57</td><td>49.13</td><td>13.2</td></tr>
<tr><td>K</td><td>19</td><td>K-series</td><td>2.77</td><td>2.77</td><td>1.06</td><td>0.1</td></tr>
<tr><td>Ca</td><td>20</td><td>K-series</td><td>2.28</td><td>2.28</td><td>0.85</td><td>0.1</td></tr>
<tr><td>S</td><td>16</td><td>K-series</td><td>1.75</td><td>1.75</td><td>0.81</td><td>0.1</td></tr>
<tr><td>Cl</td><td>17</td><td>K-series</td><td>1.47</td><td>1.47</td><td>0.62</td><td>0.1</td></tr>
<tr><td>Si</td><td>14</td><td>K-series</td><td>1.02</td><td>1.02</td><td>0.54</td><td>0.1</td></tr>
<tr><td>Na</td><td>11</td><td>K-series</td><td>0.66</td><td>0.66</td><td>0.43</td><td>0.1</td></tr>
<tr><td>Al</td><td>13</td><td>K-series</td><td>0.59</td><td>0.59</td><td>0.33</td><td>0.1</td></tr>
<tr><td>Ti</td><td>22</td><td>K-series</td><td>0.29</td><td>0.29</td><td>0.09</td><td>0.0</td></tr>
<tr><td>Mg</td><td>12</td><td>K-series</td><td>0.29</td><td>0.29</td><td>0.18</td><td>0.0</td></tr>
<tr><td></td><td></td><td>Total:</td><td>100.00</td><td>100.00</td><td>100.00</td><td></td></tr>
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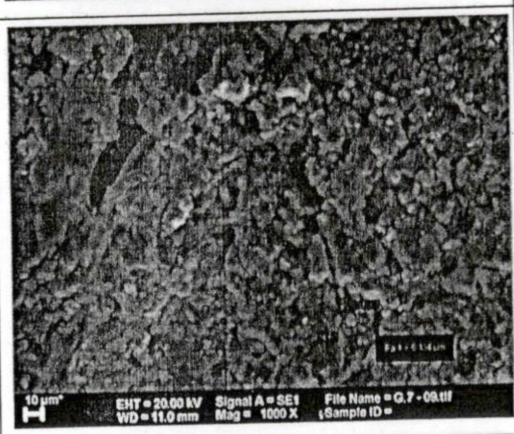
<tr><td>G_7</td><td>
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<tr><td>O</td><td>8</td><td>K-series</td><td>51.53</td><td>51.53</td><td>47.83</td><td>16.4</td></tr>
<tr><td>C</td><td>6</td><td>K-series</td><td>38.71</td><td>38.71</td><td>47.86</td><td>13.0</td></tr>
<tr><td>K</td><td>19</td><td>K-series</td><td>3.71</td><td>3.71</td><td>1.41</td><td>0.1</td></tr>
<tr><td>S</td><td>16</td><td>K-series</td><td>2.61</td><td>2.61</td><td>1.21</td><td>0.1</td></tr>
<tr><td>Cl</td><td>17</td><td>K-series</td><td>1.30</td><td>1.30</td><td>0.55</td><td>0.1</td></tr>
<tr><td>Na</td><td>11</td><td>K-series</td><td>0.68</td><td>0.68</td><td>0.44</td><td>0.1</td></tr>
<tr><td>Ca</td><td>20</td><td>K-series</td><td>0.63</td><td>0.63</td><td>0.23</td><td>0.0</td></tr>
<tr><td>Mg</td><td>12</td><td>K-series</td><td>0.40</td><td>0.40</td><td>0.25</td><td>0.1</td></tr>
<tr><td>Si</td><td>14</td><td>K-series</td><td>0.28</td><td>0.28</td><td>0.15</td><td>0.0</td></tr>
<tr><td>Al</td><td>13</td><td>K-series</td><td>0.14</td><td>0.14</td><td>0.08</td><td>0.0</td></tr>
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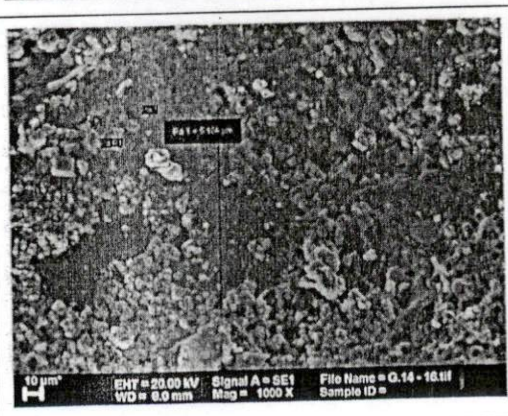
<tr><td>G_{14}</td><td>
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<tr><th>El</th><th>AN</th><th>Series</th><th>unn. C [wt. %]</th><th>norm. C [wt. %]</th><th>Atom. C [at. %]</th><th>Error [%]</th></tr>
<tr><td>O</td><td>8</td><td>K-series</td><td>55.05</td><td>55.05</td><td>63.36</td><td>17.9</td></tr>
<tr><td>C</td><td>6</td><td>K-series</td><td>39.99</td><td>39.99</td><td>34.56</td><td>12.8</td></tr>
<tr><td>S</td><td>16</td><td>K-series</td><td>1.65</td><td>1.65</td><td>0.71</td><td>0.1</td></tr>
<tr><td>Cl</td><td>17</td><td>K-series</td><td>1.30</td><td>1.30</td><td>0.51</td><td>0.1</td></tr>
<tr><td>K</td><td>19</td><td>K-series</td><td>0.81</td><td>0.81</td><td>0.28</td><td>0.1</td></tr>
<tr><td>Si</td><td>14</td><td>K-series</td><td>0.51</td><td>0.51</td><td>0.25</td><td>0.0</td></tr>
<tr><td>Ca</td><td>20</td><td>K-series</td><td>0.28</td><td>0.28</td><td>0.10</td><td>0.0</td></tr>
<tr><td>Na</td><td>11</td><td>K-series</td><td>0.19</td><td>0.19</td><td>0.11</td><td>0.0</td></tr>
<tr><td>Al</td><td>13</td><td>K-series</td><td>0.14</td><td>0.14</td><td>0.07</td><td>0.0</td></tr>
<tr><td>Mg</td><td>12</td><td>K-series</td><td>0.08</td><td>0.08</td><td>0.04</td><td>0.0</td></tr>
<tr><td></td><td></td><td>Total:</td><td>100.00</td><td>100.00</td><td>100.00</td><td></td></tr>
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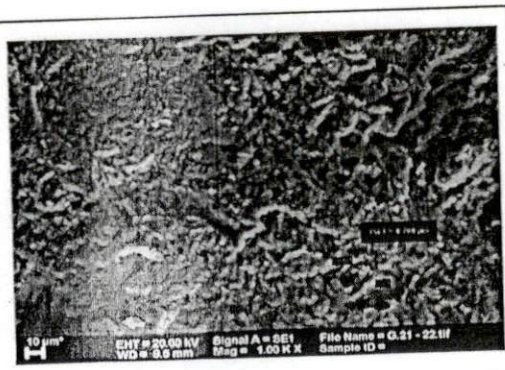
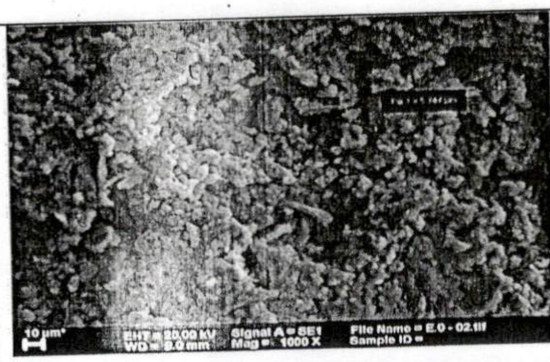
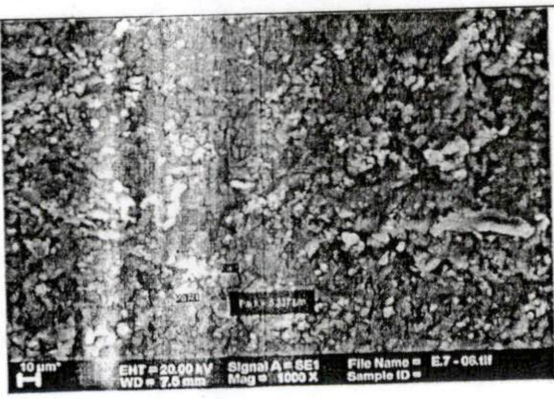
G_{21}		Mineral content (below)

El	AN	Series	unn. C [wt. %]	norm. C [wt. %]	Atom. C [at. %]	Error [%]
O	8	K-series	52.19	52.19	50.25	16.7
C	6	K-series	33.45	33.45	42.91	11.4
K	19	K-series	5.13	5.13	2.02	0.2
Cl	17	K-series	3.13	3.13	1.36	0.1
S	16	K-series	2.61	2.61	1.25	0.1
Na	11	K-series	1.71	1.71	1.15	0.1
Al	13	K-series	1.22	1.22	0.69	0.1
Mg	12	K-series	0.57	0.57	0.36	0.1
			Total: 100.00	100.00	100.00	

Figure 1. Structure porosity and mineral content from the shape of green polybag shows that performance seaweed waste of *Gracilaria verrucosa* (G0: treatment on 0 day; G7: treatment on 7 days; G14: treatment on 14 days; G21: treatment on 21 days).

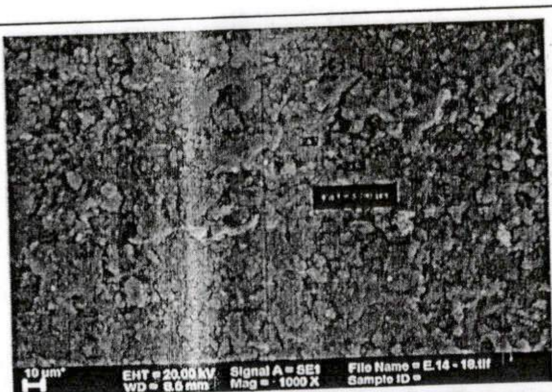
Treatment	Structure Porosity	Mineral Content
K0		Mineral content (below)

El	AN	Series	Unn [wt.%]	C norm. [wt.%]	C Atom [at. %]	C Error [%]
C	6	K-series	53.32	53.32	62.65	17.4
O	8	K-series	38.18	38.18	33.68	12.4
Cl	17	K-series	3.53	3.53	1.40	0.1
K	19	K-series	1.99	1.99	0.72	0.1
S	16	K-series	1.60	1.60	0.70	0.1
Na	11	K-series	1.18	1.18	0.72	0.1
Mg	12	K-series	0.21	0.21	0,12	0.0
		Total	100.00	100.00	100.00	

K7		Mineral content (below)

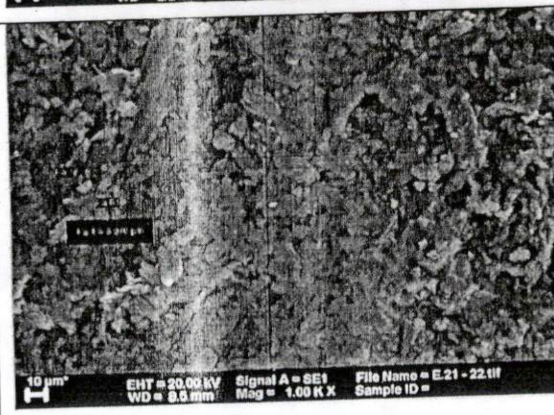
El	AN	Series	Unn [wt.%]	C norm. [wt.%]	C Atom [at. %]	C Error [%]
C	6	K-series	65.48	65.48	72.58	20.7
O	8	K-series	31.54	31.54	26.25	10.1
Cl	17	K-series	1.46	1.46	0.55	0.1
K	19	K-series	1.40	1.40	0.58	0.1
S	16	K-series	0.11	0.11	0.04	0.0
Na	11	K-series	0.01	0.01	0.00	0.0
Mg	12	K-series	0.00	0.00	0.00	0.0
		Total	100.00	100.00	100.00	

K14



El	AN	Series	Unn [wt.%]	C norm. [wt.%]	C Atom [at. %]	C Error [%]
C	6	K-series	58.24	58.24	66.29	18.8
O	8	K-series	37.35	37.35	31.91	11.9
Cl	17	K-series	1.94	1.94	0.75	0.1
K	19	K-series	1.78	1.78	0.76	0.1
S	16	K-series	0.47	0.47	0.17	0.0
Na	11	K-series	0.20	0.20	0.12	0.0
Mg	12	K-series	0.01	0.01	0.01	0.0
		Total	100.00	100.00	100.00	

K21



El	AN	Series	Unn [wt.%]	C norm. [wt.%]	C Atom [at. %]	C Error [%]
C	6	K-series	59.84	59.84	67.37	19.3
O	8	K-series	37.24	37.24	31.47	11.9
Cl	17	K-series	1.30	1.30	0.55	0.1
K	19	K-series	1.06	1.06	0.40	0.1
S	16	K-series	0.51	0.51	0.18	0.0
Na	11	K-series	0.05	0.05	0.03	0.0
Mg	12	K-series	0.00	0.00	0.00	0.0
		Total	100.00	100.00	100.00	

Figure 2. Structure porosity and mineral content from the shape of green polybag shows that performance seaweed waste of *Kappaphycus alvarezii* (K0: treatment on 0 day; K7: treatment on 7 days; K14: treatment on 14 days; K21: treatment on 21 days.

Table 1. Data of soil quality.

Parameter	Range
Temperature (°C)	27 – 29
Humidity (pF)	3.0 – 6.2
pH	6.5 – 7

The physical data of the soil quality showed that the temperature, humidity and pH of the soil were normal for optimum growth of plants. Based on the results of this research, the waste of *K. alvarezii* and G. *verrucosa* can be used as raw materials of green polybag of MDF.

4. Conclusion

We demonstrated that *K. alvarezii* and G. *verrucosa* can be used as raw materials of green polybag of MDF. The porosity sizes of *K. alvarezii* and *G. verrucosa* were 3.976 µm and 4.794 µm, respectively. The carbon content was greater than 50% in *K. alvarezii,* and less than 50% in *G. verrucosa*. Therefore, the

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structure of MDF is stronger in green polybag made from the waste of *K. alvarezii* than that in green polybag made from *G. verrucosa*.

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